Review of "fluoride contamination and health risk assessment of groundwater"

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***Abstract*- Fluoride intake has always been considered a key factor for prevention of dental caries and improvement of public dental health. Fluoride makes the tooth-enamel surface acid resistant by preventing bacterial demineralization and promotes re-mineralization of initial non-cavitated carious lesions. It also shows antimicrobial activity; in low concentrations it prevents bacterial adhesion to tooth structure while in high concentration the fluoride ion is highly toxic to certain oral microorganisms. It becomes imperative to estimate whether fluoride levels in drinking water are within the recommended and accepted levels to prevent dental caries and reduce the risk of dental fluorosis. To our knowledge this is the first study conducted in Central India region to determine the fluoride content in drinking water. Thus, the objective can be summarized as:**

"To review on Health Risk Assessment due to fluoride concentration in drinking water which include ground and surface water in central India."

Index Terms- Ground Water, HQ, EDI, Health Risk Assessment, Fluoride Concentration, SPADNS.

I. INTRODUCTION

1.1 General

Our environment consists of physical, chemical, and biological substances, which interact so that the physical and chemical substances support the biological substances and allow them to experience sustainable growth. At the present level of human advancement, mankind is able to negatively and positively influence the balance of these substances, thereby affecting the health of the environment.

Discharges from human activity must be released to the air, the water or the soil. Each of these potential reservoirs can accept a limited amount of physical, chemical and biological substances without significant deterioration. Beyond this point of assimilation, the environment can be deteriorated to the point that sustainable biological growth cannot occur.

This deterioration can be caused by the weather in the form of wind (i.e. dust blown into the air), rain (i.e. storm water eroding soil into the water and floods depositing solids), lightning (i.e. fires discharging smoke and particulates into the air and water and ash onto the soil), or volcanoes (smoke and particulates discharged into the air and water into the soil). The deterioration can also be caused by vegetation (hydrocarbon vapours discharged into the air and dissolved hydrocarbons running into the water), animals (faces polluting the water, flatus passing into the air), and activities of humans.

Water as a reservoir, can provide minimal treatment to certain organic pollutants because of the oxygen and the biota in the water. Water also acts as a disperser of pollutants. Water pollutant dispersion is easier to model since it flows in a defined channel with a predictable velocity. Water pollution can be of regional interest because of this dispersion.

The discharge of pollutants onto or into the soil is normally of only local concern since liquid migrations is soil is slow. Soil pollution is normally only of concern when the pollutant is liquid or is a soluble solid. An insoluble solid will not migrate except through underground channels, nor will it dissolve into groundwater.

The major concern with soil pollution is the subsequent pollution of the groundwater when the groundwater is used as a source of water for drinking, irrigation or industrial use.

1.2 Water Quality

"Water quality" is a term used here to express the suitability of water to sustain various uses or processes. Any particular use will have certain requirements for the physical, chemical or biological characteristics of water; for example, limits on the concentrations of toxic substances for drinking water use, or restrictions on temperature and pH ranges for water supporting invertebrate communities. Consequently, water quality can be defined by a range of variables which limit water use. Although many uses have some common requirements for certain variables, each use will have its own demands and influences on water quality. Quantity and quality demands of different users will not always be compatible, and the activities of one user may restrict the activities of another, either by demanding water of a quality outside the range required by the other user or by lowering quality during use of the water. Efforts to improve or maintain a certain water quality often compromise between the quality and quantity demands of different users. There is increasing recognition that natural ecosystems have a legitimate place in the consideration of options for water quality management. This is both for their intrinsic value and because they are sensitive indicators of changes or deterioration in overall water quality, providing a useful addition to physical, chemical and other information.

The composition of surface and underground waters is dependent on natural factors (geological, topographical, meteorological, hydrological and biological) in the drainage basin and varies with seasonal differences in runoff volumes, weather conditions and water levels. Large natural variations in water quality may, therefore, be observed even where only a single watercourse is involved. Human intervention also has significant effects on water quality. Some of these effects are the result of hydrological changes, such as the building of dams, draining of wetlands and diversion of flow. More obvious are the polluting activities, such as the discharge of domestic, industrial, urban and other wastewaters into the water-course (whether intentional or accidental) and the spreading of chemicals on agricultural land in the drainage basin.

Water quality is affected by a wide range of natural and human influences. The most important of the natural influences are geological, hydrological and climatic, since these affect the quantity and the quality of water available. Their influence is generally greatest when available water quantities are low and maximum use must be made of the limited resource; for example, high salinity is a frequent problem in arid and coastal areas. If the financial and technical resources are available, seawater or saline groundwater can be desalinated but, in many circumstances, this is not feasible. Thus, although water may be available in adequate quantities, its unsuitable quality limits the uses that can be made of it. Although the natural ecosystem is in harmony with natural water quality, any significant changes to water quality will usually be disruptive to the ecosystem.

The effects of human activities on water quality are both widespread and varied in the degree to which they disrupt the ecosystem and/or restrict water use. Pollution of water by human faeces, for example, is attributable to only one source, but the reasons for this type of pollution, its impacts on water quality and the necessary remedial or preventive measures are varied. Faecal pollution may occur because there are no community facilities for waste disposal, because collection and treatment facilities are inadequate or improperly operated, or because on-site sanitation facilities (such as latrines) drain directly into aquifers. The effects of faecal pollution vary. In developing countries intestinal disease is the main problem, while organic load and eutrophication may be of greater concern in developed countries (in the rivers into which the sewage or effluent is discharged and in the sea into which the rivers flow or sewage sludge is dumped). A single influence may, therefore, give rise to a number of water quality problems, just as a problem may have a number of contributing influences.

1.3 Sources of Water Pollution

The life and activities of plants and animals, including humans, contribute to the pollution of the earth, assuming that pollution is defined as the deterioration of the existing state.

1.3.1 Industrial Sources of Water Pollution

Any industry, in which water obtained from a water treatment system or a well comes in contact with a process or product can add pollutants to the water. The resulting water is then classified as a wastewater.

The industries can be classified into Standard Industrial Classifications (SIC). Industries in any of these classifications can contribute to water pollution as their water supply is used in a process.

The following are examples of industrial water pollution sources:

Non-Contact Water

- Boiler feed water
- Cooling water
- Heating water
- Cooling condensate

Contact Water

- Water used to transport products, materials or chemicals
- Washing and rinsing water (product, equipment, floors)
- Solubilizing water
- Diluting water
- Direct contact cooling or heating water
- Sewage
- Shower and sink water

The wastewater can contain physical, chemical and/or biological pollutants in any form or quantity and cannot adequately be quantified without actual measuring and testing. The wastewater will typically either be discharged directly into a receiving body of water or into the sewerage system of a municipality, or it will be reused or recycled.

1.3.2 Municipal Sources of Water Pollution

The non-industrial municipal sources of water are typically as follows:

- Dwellings
- Commercial establishments
- Institutions (schools, hospitals, prisons, etc)
- Governmental operations

It is assumed that a non-industrial municipal wastewater source will contain no pollutants except for the following:

- Feces
- Urine
- Paper
- Food waste
- Laundry wastewater
- Sink, shower, and bath water

These pollutants are all biological and as such can be readily biodegraded. Any extraneous nonindustrial pollutants other than those listed above can be physical or chemical in nature, and ideally should be prevented from entering a municipal system with a Pre-treatment Ordinance or removed from the municipal wastewater using some method of pre-treatment.

1.3.3 Agricultural Sources of Water Pollution

Normally, agricultural water pollutants are transported to an aboveground or underground receiving stream by periodic storm water. Agricultural wastewater can be of animal or vegetable origin or be from a nutrient, fertilizer, pesticide or herbicide source. Animal or vegetable sources will be limited to biodegradable feces, urine or vegetable constituents. Nutrients or fertilizers will be typically some formulation of carbon, phosphorous, nitrogen and/or trace metals. Pesticides and herbicides will consist of formulated organic chemicals, many with complex molecular structures, designed to be very persistent in the environment. Pesticides such as Chlorodane and Heptachlor, which consist of a multitude of different organic chemicals, can still exist in the soil around World War II barracks. Agricultural activities can also allow the runoff of soil into receiving streams. In such cases, pollutants can be any organic or inorganic constituent of the soil.

1.3.4 Natural Sources of Water Pollution

Areas unaffected by human activity can still pollute receiving steams due to storm water runoff, which can be classified into animal, vegetable and soil sources. Again, animal and vegetable water pollution sources should be readily biodegradable. Soil sources will consist of any organic and inorganic material in the soil.

1.3.5 Landfill Water Pollution Sources

Public, private, and industrial landfills can be a source of storm water pollution because of runoff from the surface and underground leachate. Landfill regulations require daily cover, but during the day, rainfall can cause pollution from surface runoff. When storm water leaches through the surface cap and downward through the landfill, the horizontally or vertically migrating discharge from below the landfill is known as leachate and can pollute surface or underground water. Because of the bacteria present in the dirt and in landfill material, there will always be aerobic and anaerobic biological activity occurring in a landfill.

1.4 Characteristics of groundwater

Groundwater is held in the pore space of sediments such as sands or gravels or in the fissures of fractured rock such as crystalline rock and limestone. The body of rock or sediments containing the water is termed an aquifer and the upper water level in the saturated

body is termed the water table. Typically, groundwaters have a steady flow pattern. Velocity is governed mainly by the porosity and permeability of the material through which the water flows and is often up to several orders of magnitude less than that of surface waters. As a result, mixing is poor.
The media (rock or sediment) in an aquifer are characterised by porosity and permeability. Porosity is the ratio of pore and fissure volume to the total volume of the media. It is measured as percentage voids and denotes the storage or water volume of the media. Permeability is a measure of the ease with which fluids in general may pass through the media under a potential gradient and indicates the relative rate of travel of water or fluids through media under given conditions. For water it is termed hydraulic conductivity.

Types of aquifer
Underground formations are of three basic types: hard crystalline rocks, consolidated sedimentary formations and unconsolidated sediments. The hard-crystalline rocks include granites, gneisses, schists and quartzites and certain types of volcanic rocks such as basalts and dolerites. These formations generally have little or no original porosity, and the existence of aquifers depends on fractures and fissures in the rock mass providing porosity and pathways for groundwater movement. Although these are often further enhanced by weathering, aquifers in hard rocks are usually small and localised and not very productive. Groundwater in volcanic formations in regions of "recent" volcanic activity frequently contains fluoride and boron in concentrations that are unacceptably high for certain uses.

Water quality
The quality of groundwater depends on the composition of the recharge water, the interactions between the water and the soil, soil-gas and rocks with which it comes into contact in the unsaturated zone, and the residence time and reactions that take place within the aquifer. Therefore, considerable variation can be found, even in the same general area, especially where rocks of different compositions and solubility occur.

Contamination
Artificial pollution of groundwater may arise from either point or diffuse sources. Some of the more common sources include domestic sewage and latrines, municipal solid waste, agricultural wastes and manure, and industrial wastes (including tipping, direct injection, spillage and leakage). The contamination of ground-waters can be a complex process. Contaminants, such as agricultural chemicals, spread over large sections of the aquifer recharge area may take decades to appear in the groundwater and perhaps longer to disappear after their use has ceased. Major accidental spills and other point sources of pollutants may initially cause rapid local contamination, which then spreads through the aquifer. Pollutants that are fully soluble in water and of about the same density (such as chloride-contaminated water from sewage) will spread through the aquifer at a rate related to the groundwater flow velocity. Pollutants that are less dense than water will tend to accumulate at the water table and flow along the surface. Dense compounds such as chlorinated solvents will move vertically downwards and accumulate at the bottom of an aquifer.

II-LITERATURE REVIEW

Various researchers have been carried out their study for the same field, some of them are as:
"Groundwater quality analysis of quaternary aquifers in Jhajjar District, Haryana, India: Focus on groundwater fluoride and health implications", 2018, Ruchi Gupta, Anil Kumar Misra
Several types of health problems in Jhajjar district of Haryana state are prevailing owing to groundwater quality problems such as high concentration of fluoride, chloride, salinity, TDS, etc. The objective of this work was to assess the overall groundwater quality of the district based on Water Quality Index (WQI) and find out the factors leading to continuous deterioration in groundwater quality. The study demonstrates that groundwater quality of Jhajjar district is totally unsuitable for drinking purposes and is directly or indirectly influenced by geogenic factors. About 60–70% of the samples analysed show high fluoride content. Other parameters such as hardness, electrical conductivity, Total Dissolved Solids (TDS), and Chloride are also above the permissible limits. Hydro-geologically the study area belongs to Indo-Gangetic alluvial plains, which are

dominated by clay-silt, clay and grey micaceous sand formations. Clay rich formations are rich in fluorine and other salts and their weathering is most probably causing the continuous escalation in the fluoride and salinity concentration in groundwater. Several in-situ and ex-situ measures have been suggested for remediation and to prevent further escalation of water quality problems that are needed imperatively for the sustainable development of water resources.

"Data on fluoride contents in ground water of Bushehr province", Iran Sina Dobaradaran, MaryamKhorsand, Abdolreza Hayati, Roya Moradzadeh, Mohammad Pouryousefi, MostafaAhmadi, 2018, Data in Brief17(2018)1158–1162

In this article, we measured the levels of fluoride in ground water. The samples were taken from ground-water in Bushehr's province, Iran. After the collection of samples, the concentration levels of fluoride were determined by the standard SPADNS method using spectrometer. The mean concentration levels of fluoride in water of all stations were higher than the WHO drinking water guide line. Microsoft Office Excel2016 was used for calculation of mean values. The mean concentration level of fluoride in statement were in therangeof1.52to3.64mgl-1.

"Determining the optimum locations for pumping low-fluoride groundwater to distribute to communities in a fluoridic area in the Upper East Region, Ghana", Laura Craig, James M. Thomas, Alexandra Lutz, David L. Decker, 2018

Groundwater is the primary source of water in the Upper East Region of Ghana and is generally considered a safe source of drinking water; but there are pockets where the groundwater contains high concentrations of fluoride due to the dissolution of minerals in the local granite. The goal of this study is to evaluate the hydrogeology and hydro geo-chemistry of an area where dental fluorosis endemic, in order to identify the optimum locations to pump and distribute low-fluoride groundwater. As expected, the data indicate that the higher elevation recharge areas with outcrops of Bongo granite have elevated concentrations of fluoride in the groundwater (up to 4.6 mg L−1), posing the highest risk of fluorosis in the nearby communities. The lower elevation areas, which are the farthest from the Bongo granitic, have the lowest groundwater fluoride (< 0.5 mg L−1) and the lowest risk of fluorosis. Groundwater flow models suggest that the steady decrease in fluoride is driven by dispersion, with the fluoride concentrations dropping to the World Health Organization's recommended drinking water limit of 1.5 mg L−1 at about 400–500 m from the source. The optimum locations to install boreholes (or use existing boreholes) for piping low fluoride groundwater to the higher fluoride areas, would be at or beyond this distance. Although the initial costs of developing such a water system would be substantial, this is a potentially viable option for providing low fluoride water to communities suffering from fluorosis.

Gayatri Singh, Babita Kumari, Geetgovind Sinam, Kriti, Navin Kumar, Shekhar Mallick, "Fluoride distribution and contamination in the water, soil and plants continuum and its remedial technologies, an Indian perspective- a review", 2018

Fluorine is an essential element required in trace amounts but gets toxic for human beings at levels more than 1.5mg F_ L_1 primarily through drinking contaminated water. It is the 13th most abundant element and constitutes about 0.06e0.09% in the earth crust. It is electronegative in aqueous medium forming fluoride ion (F_). Fluoride contamination in the environment occurs mostly due to anthropogenic and geogenic sources. Fluoride is widely distributed in all components of environment, air (0.1-0.6 mg L_1) soils (150e400mg Kg_1) rocks (100e2000 mg Kg_1), plant (0.01e42 mg Kg_1) and water (1.0 e38.5 mg L_1). Human beings and animals are being exposed to F_ primarily from water (0.2 -42.0 mg L_1) and plants (0.77-29.5 mg g_1). Fluorosis, a health hazard due to F_ is a major problem in many countries across the world affecting about 200 million people globally. In India, > 62 million people in twenty states are facing problem due to F_. The most affected states are Rajasthan (7670 habitations), Telangana (1,174 habitations) and Karnataka (1122 habitations). To mitigate this problem, there is an urgent need to understand the current status and brief knowledge of F_ geochemistry. The objective of this review is to highlight different sources of F_ that contaminate different environmental matrices including plants, the extent of contamination level in India, uptake, translocation and toxicity mechanism in plants. The review also highlights currently available mitigation methods or technologies through physio-chemical and biological means.

"A hybrid method for the removal of fluoride from drinking water: Parametric study and cost estimation", 2018, M. Changmai, M. Pasawan, M.K. Purkait

A hybrid technique (electrocoagulation followed by microfiltration) was utilized for an efficient de-fluoridation of contaminated drinking water. Three samples of drinking water with an initial fluoride concentration of 7.89, 4.79 and 1.78 mg/L were collected from a hand tube well located in Karbi Anglong district of Assam, India. Effects of different operational parameters such as initial fluoride concentration, current density and pH on the removal of fluoride were extensively investigated in the electrocoagulation chamber. For a current density of 15 A/m2 and an electrode distance of 0.005 m, an efficient removal of 0.0097, 0.335 and 0.656 mg/L was observed for initial fluoride concentration of 1.78, 4.79 and 7.89 mg/L, respectively. The uptake of fluoride was the highest at pH = 7.9 with a final fluoride concentration of 0.43 mg/L. Filtration studies were performed using indigenously prepared membrane. An increase in flux from 7.98 × 10-5 to 19.19 × 10-5 m3/m2.s was observed with an increase in transmembrane from 196 to 509 kPa. Produced flocs were scraped from the membrane surface, dried and characterized to confirm the presence of fluoride. The proposed hybrid technique was able to lower the concentration of fluoride from contaminated drinking water within the permissible limit as per WHO of 1.5 mg/L.

III.CONCLUSION

Several types of health problems in Madhya Pradesh state are prevailing owing to groundwater quality problems such as high concentration of fluoride, chloride, salinity, TDS, etc. In this study Fluoride concentrations have been identified, the other factors like chloride, salinity, TDS, etc can also be identified for the complete study.

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